Space Weather Technical Forecast

Issued on Monday, 27 February 2023 at 01:38 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1/Minor to G2/Moderate storms expected, and chance G3/Strong storms 27-28 Feb. R1-R2 Blackouts likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with several low levels C-class flares in the last 24 hours. There are eight sunspot regions on the visible disc. AR3234 in the north near the central meridian remains the longest and largest spot at present. It has shown little change recently, still containing a 'delta' spot within its trailer portion. AR3236 in the southwest quadrant is the second largest region on the disc, though showing recent decay, now having lost it's 'delta' configuration. AR3229 has shown continued decay also, though it's magnetic field lines remain complex. A new region has recently rotated onto the northeast of the disk, current analysis has this as a small and simple region. The other remaining regions on the disc are also small and simple.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as measured by DSCOVR and ACE at L1, were indicative of the arrival of a CH HSS followed by a CME. Solar winds rose erratically from 420 km/s to around 700 km/s. Density was mostly above average with a peak of 33ppcc at 26/0700 UTC, and then 32ppcc at 26/2018 UTC. The total IMF strength, Bt, started weak, becoming mostly moderate from 26/0845 UTC, then strong but on a declining trend from 26/1845 UTC when the CME arrived, with a peak of 21 nT observed at 26/2058 UTC. The north-south component was weakly positive, then became moderately negative from 26/1900 UTC, varying between +9 to -18 nT. Phi angle was mainly positive initially (away from the Sun) before becoming negative (toward the Sun) after 26/0700 UTC. Geomagnetic activity was mostly Unsettled (Kp 3) before rising to G1/Minor (Kp5) then G2/ Moderate (Kp 6) storm levels to end the period.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16, has been on a declining trend after the M6.4 flare from 25 Feb saw S1 Minor Storm levels reached. The count rate has reduced on a erratic yet continued downward trend, as of 26/2320 UTC having fallen below S1 levels. High energy electron flux (greater than 2MeV) at GOES-16 was at background levels, peaking of around 142pfu at 26/1850 UTC. The associated 24-hour electron fluence has been below the Active (1e8 integrated pfu) threshold, falling to 2.2e6 integrated pfu at 27/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is considered likely, with M-flares (R1-R2), and a slight chance of increasing to High if any X-flares occur (R3).

Solar Wind / Geomagnetic Activity: A CME left the Sun around 25/1930 UTC associated with a M6.3 flare from AR3229. The arrival of which is expected to be during the second half of 27 Feb or perhaps on 28 Feb.

The Earth is currently under the combined effects of the HSS of CH79/- and a CME which left the Sun on 24 Feb. Solar wind speeds are expected to gradually decline through 27 Feb back to

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Elevated before the arrival of the CME from 25 Feb, raising wind speeds to Strong once again. Speeds then waning though 01 and 02 Mar back to Slightly Elevated or Background.

Geomagnetic activity is currently at G2/Moderate storm levels, with a continued risk of G3/Strong Storm intervals early in the period. CME effects are expected to ease, allowing geomagnetic activity to return to Unsettled or Active during 27 Feb before the CME from 25 Feb arrives, bringing further G1/Minor or G2/Moderate storms and a chance of G3/Strong storms later on 27 Feb or on 28 Feb. Geomagnetic activity should then decline from 01 Mar, back to Quiet to Active, with a reducing chance of G1/Minor storms.

Energetic Particles / Solar Radiation: The count rate of energetic particles (high energy protons) has now fallen below the S1 Minor Storm level. There is a reducing chance of further proton events through the period, either from AR3229 or AR3234. High energy electron flux (greater than 2MeV) observed at GOES16 has become moderate to background levels. This will likely whilst CME and CH HSS influence combine during 27 and 28 Feb. As elevated winds decline later in the period, these may begin to recover, with flux increasing to Moderate, and perhaps High (above 1000 pfu) from 01 Mar. The associated 24 hour fluence is consequently expected to persist at background for much of the period, with an increasing chance of reaching Active levels from 01 Mar due to a recovery post CH HSS and CME arrivals.

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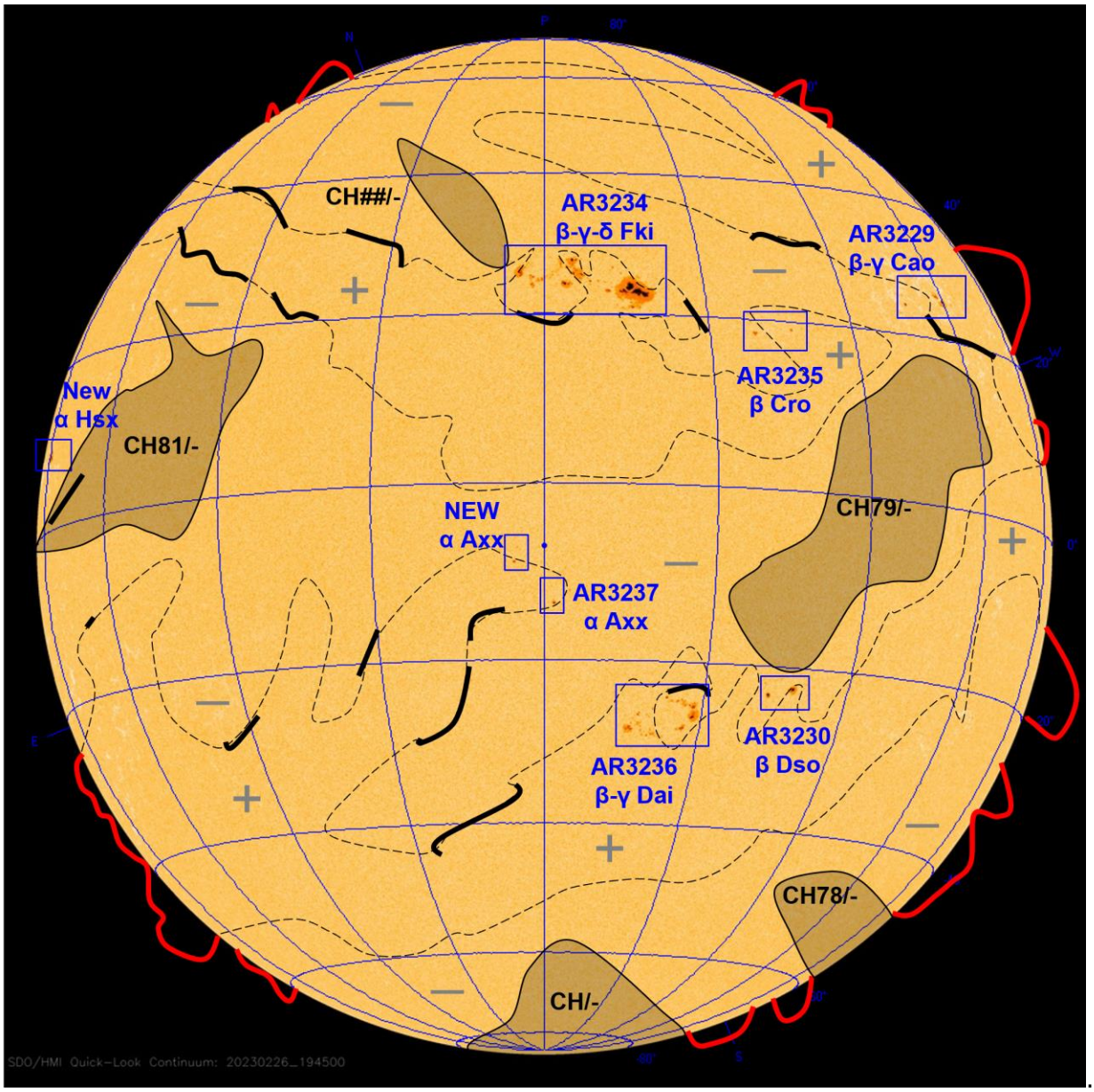
Figure 1. Solar Analysis Valid 26/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME left the Sun around 25/1930 UTC associated with a M6.3 flare from AR3229. This created a lopsided Halo CME, with mostly westward directed ejecta, but also an Earth-directed component. A variety of speeds were attained during various analyses, but with an average arrival expected to be during the second half of 27 Feb or perhaps on 28 Feb.

The Earth is currently under the combined effects of the HSS of CH79/- and a CME which left the Sun on 24 Feb. Solar wind speeds are expected to gradually decline through 27 Feb back to Elevated before the arrival of the CME from 25 Feb, raising wind speeds to Strong once again. Speeds then waning though 01 and 02 Mar back to Slightly Elevated or Background.

The current solar wind parameters are giving a notable geomagnetic response. Geomagnetic activity is currently at G1/Minor G2/Moderate storm levels, with a continued risk of G3/Strong Storm intervals early in the period. CME effects are expected to ease, allowing geomagnetic activity to return to Unsettled or Active during 27 Feb before the CME from 25 Feb arrives, bringing further G1/Minor or G2/Moderate storms and a chance of G3/Strong storms later on 27 Feb or on 28 Feb. Geomagnetic activity should then decline from 01 Mar, back to Quiet to Active, with a reducing chance of G1/Minor storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	80	70	30	10
Strong	G3	No	30	30	5	1
Severe	G4	No	5	5	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
25/2319	Full	AR3229 M6 and filament	NE	940 km/s	27/2100 -6 +12hrs	Lopsided halo, likely Earth directed.

Figure 2: MOSWOC ENLIL

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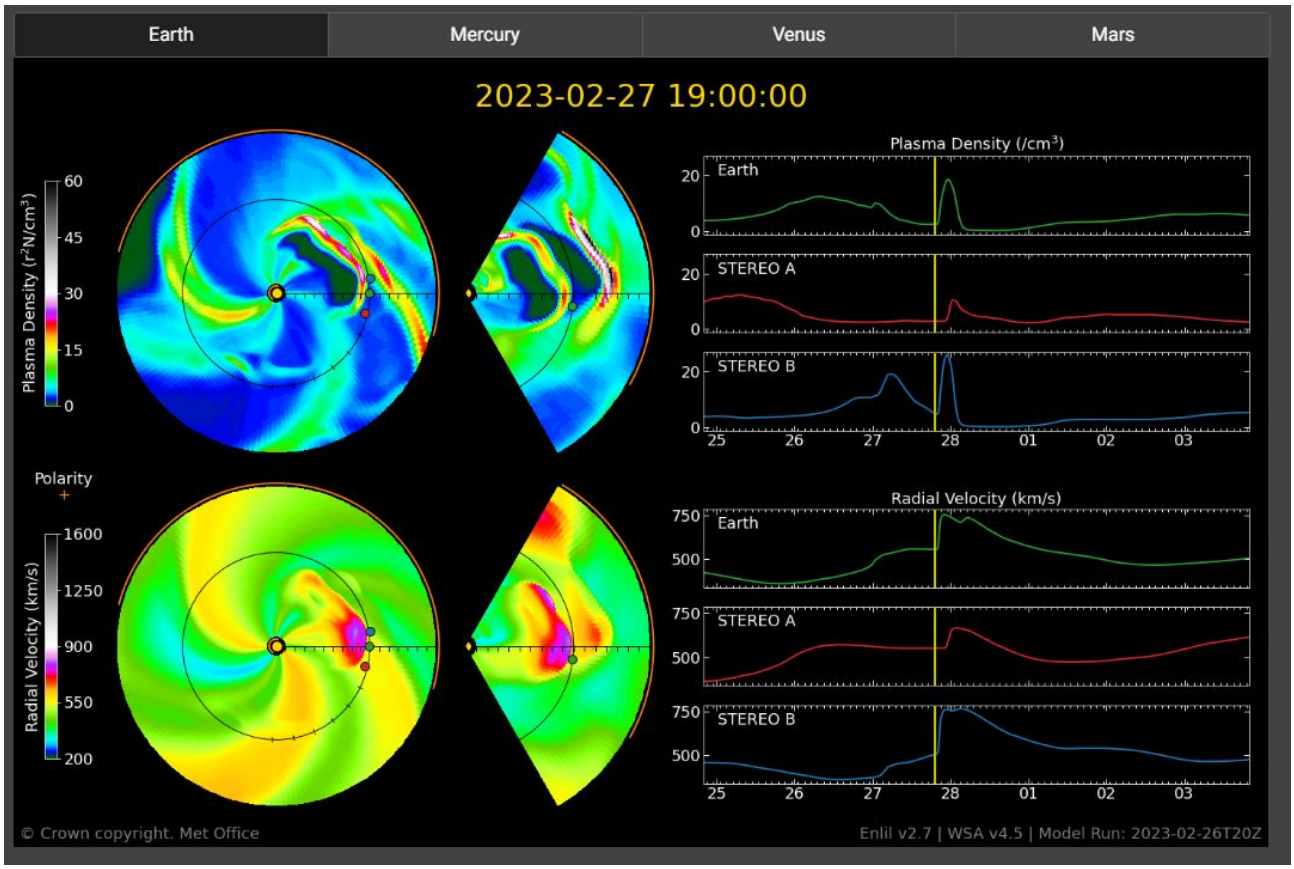

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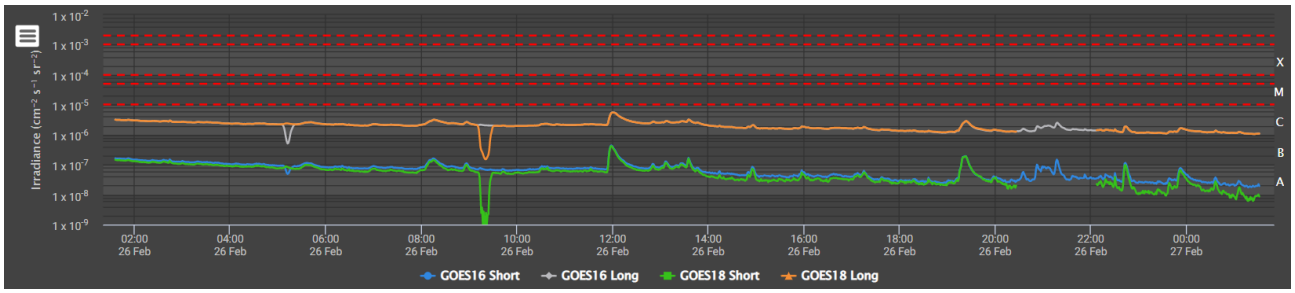
Radio Blackouts - X-Ray Flares:

Solar activity has been Low, with several low levels C-class flares in the last 24 hours. M-class flares are considered likely, with a slight chance of X-class flares. The main risk of flares is largely but not exclusively from AR3234 or AR3236.

There are eight sunspot regions on the visible disc. AR3234 in the north near the central meridian remains the longest and largest spot at present. It has shown little change recently, still containing a 'delta' spot within its trailer portion. AR3236 in the southwest quadrant is the second largest region on the disc, though showing recent decay, now having lost it's 'delta' configuration. AR3229 has shown continued decay also, though it's magnetic field lines remain complex. A new region has recently rotated onto the northeast of the disk, current analysis has this as a small and simple region. The other remaining regions on the disc are also small and simple.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	50	50
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: 24 hour X-Ray trace



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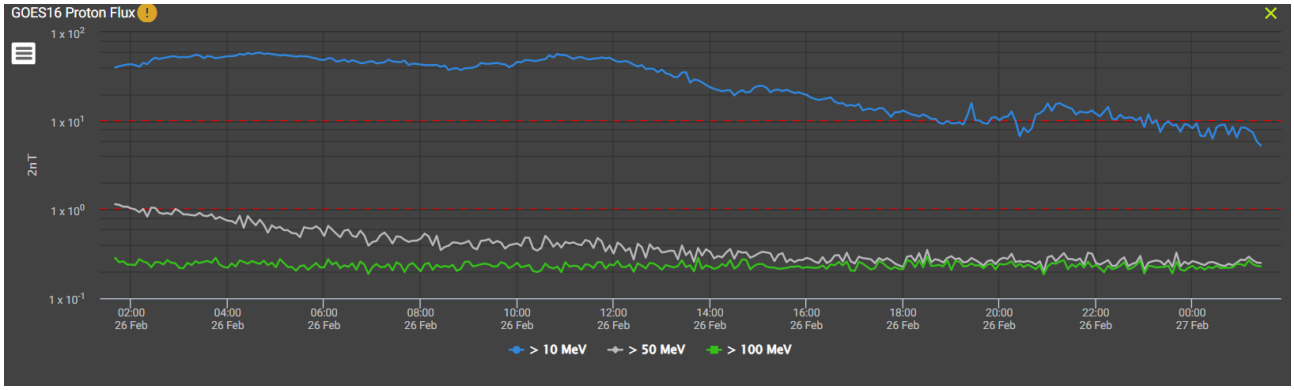
Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16, was above the S1 Storm levels for much of the period, with a peak of 58.8 pfu at 26/0440 UTC in response to the M6.4 flare and subsequent filament eruption from AR3229. The count rate has reduced on a erratic yet continued downward trend, as of 26/2320 UTC having fallen below S1 levels. There is considered a reducing chance of further proton events through the period, either from this sunspot region or from the other complex regions on the disc, including AR3234 and AR3236 which are both moving into a more geoeffective location.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	40	20	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 24 hour proton trace



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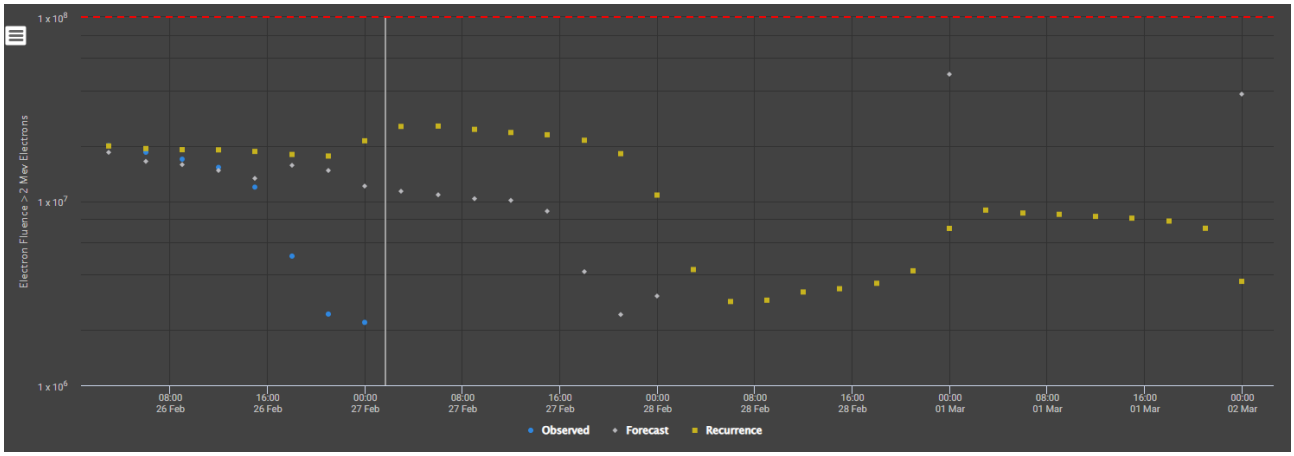
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed at GOES16 has become moderate to background levels. Coronal hole fast winds and CMEs through the end of Feb will likely combine to suppress observed flux at GEO, though perhaps increasing the electron content of the Van Allen belts which will be compressed into lower orbits. As elevated winds decline later in the period, these may begin to recover, with flux increasing to Moderate, and perhaps High (above 1000 pfu) from 01 Mar.

The associated 24 hour fluence is consequently expected to persist at background for much of the period, with an increasing chance of reaching Active levels from 01 Mar due to a recovery post CH HSS and CME arrivals. REFM is currently giving good guidance through the period with a mostly flat trend.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	20	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: MOSWOC REFM integrated flux/fluence forecast



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